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LB650 cavity RF design update

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Fermilab and IIFC collaboration web-meeting

29 March 2016

650 MHz cavities RF design and 650 MHz power coupler

- 650 MHz cavities and power coupler were developed for ProjectX:
  - CW operation
  - Beam current 1 mA
  - Coupler compatible with both types of 650 MHz cavities
- ProjectX was transformed to PIP-II with new parameters:
  - Pulsed operation
  - Beam current 2 mA
- Design of HB650 dressed cavity was changed:
  - LFD reduced
  - Tuner efficiency increased, HV stiffness increased
  - Position of power coupler was moved away from the cavity
- No funds for design of LB650 dressed cavity

LB650 cavity RF design history

- RF design of LB650 cavity was done before 2013
- No funds for LB650 dressed cavity design after 2013
- 2015 decision: VECC will manufacture LB650 cavities
  - VECC will continue LB650 design
  - FNAL transfer LB650 cavity design to VECC
  - Prepare all current LB650 cavity design documents for transfer
- Check LB650 cavity design for compatibility with:
  - 650 MHz frequency tuner
  - 650 MHz power coupler
- Transfer LB650 cavity design to VECC

Requirements for 650 MHz cavity design

Superconducting RF: Strategy and Organization

Slava Yakovlev

PIP-II Machine Advisory Committee Meeting

15-17 March 2016

- LB 650 and HB 650 design similarities implements the same strategy as SSR:
  - Mechanical Tuners and resonance control strategies
  - Low df/dP cavity and helium vessel integrated designs
  - High Power RF couplers
  - Cavity string support structure
  - Cryogenic plumbing
  - Significant number of common parts

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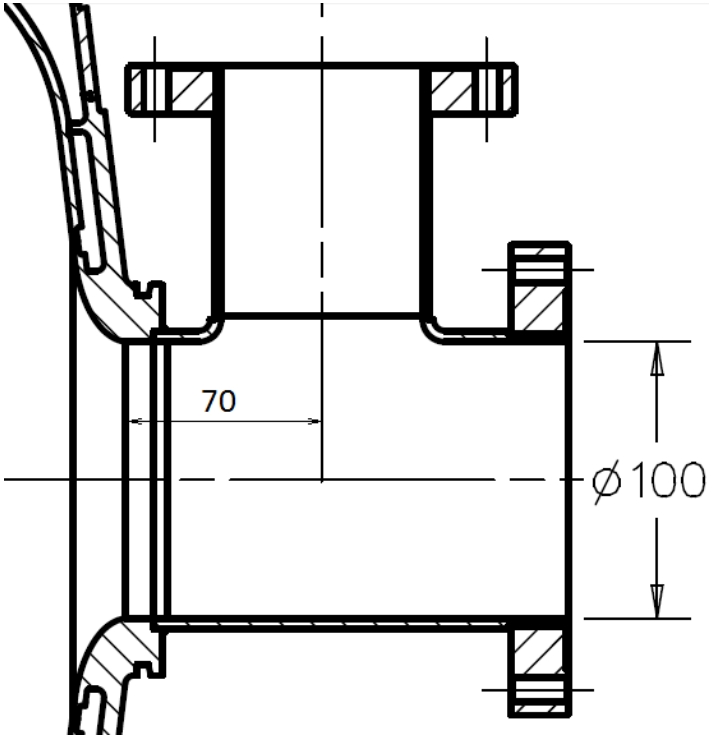
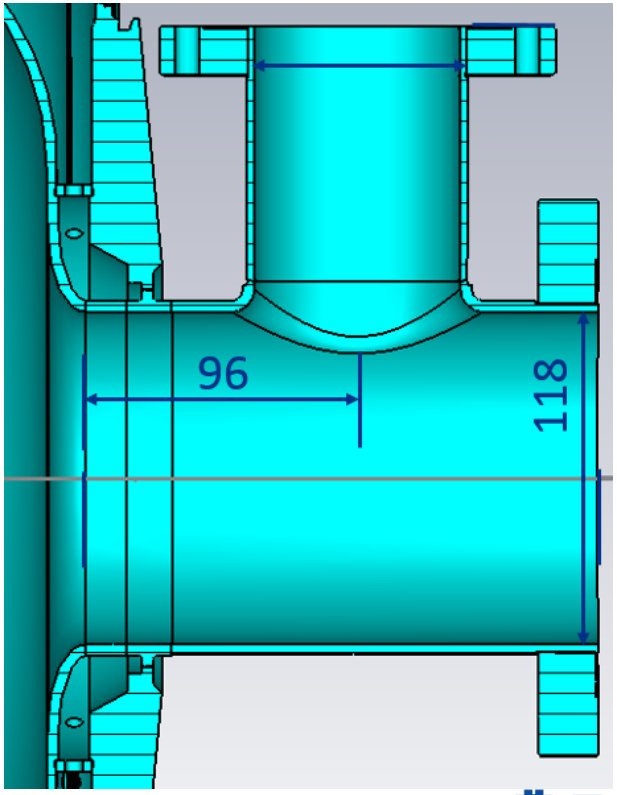
PIP-II

HB650 cavity RF design modification

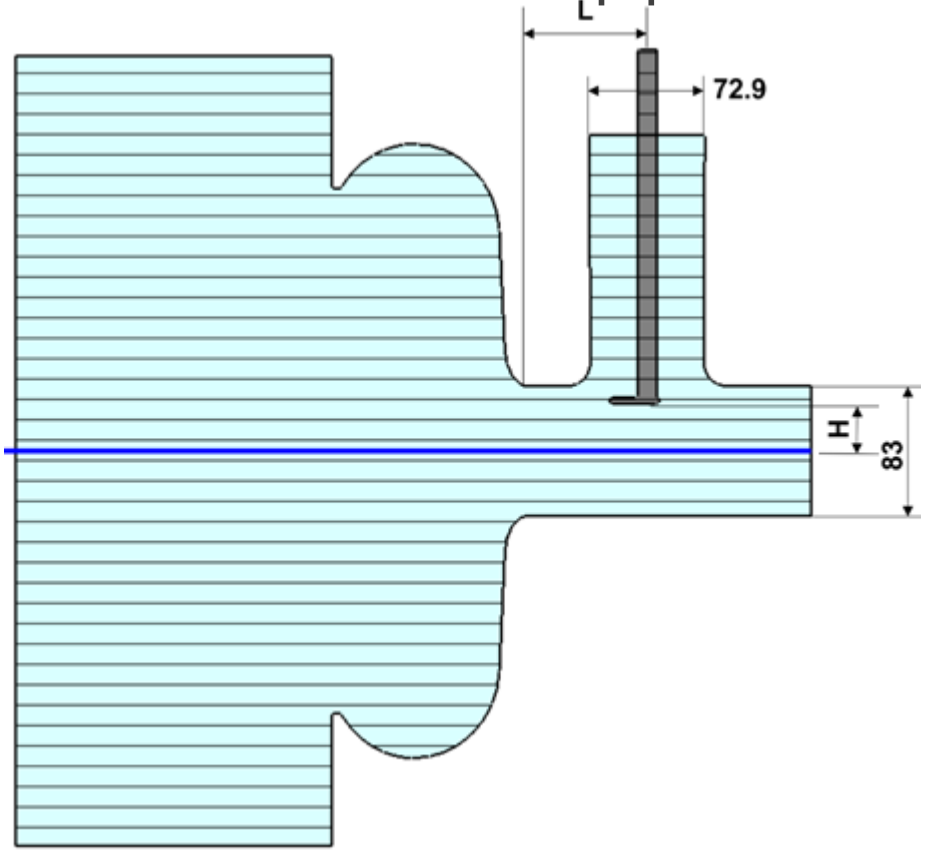
- RF design of the cavity was changed from β=0.90 to β=0.92
- Stiffening ring radius was reduced to minimize df/dP
- Conical NbTi flanges of the cavity were stiffened to reduce LFD
- Power coupler position for HB650 was moved away by 26 mm

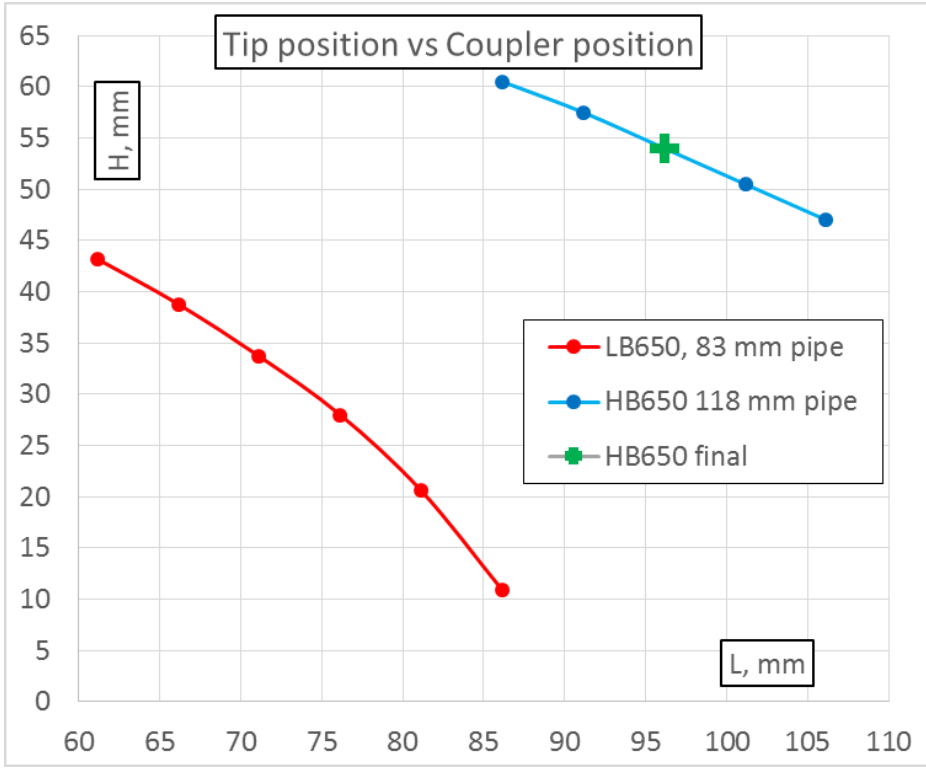




LB650 cavity RF design and 650 MHz power coupler

- No space for helium vessel of LB650 cavity
- Increase of beam pipe diameter

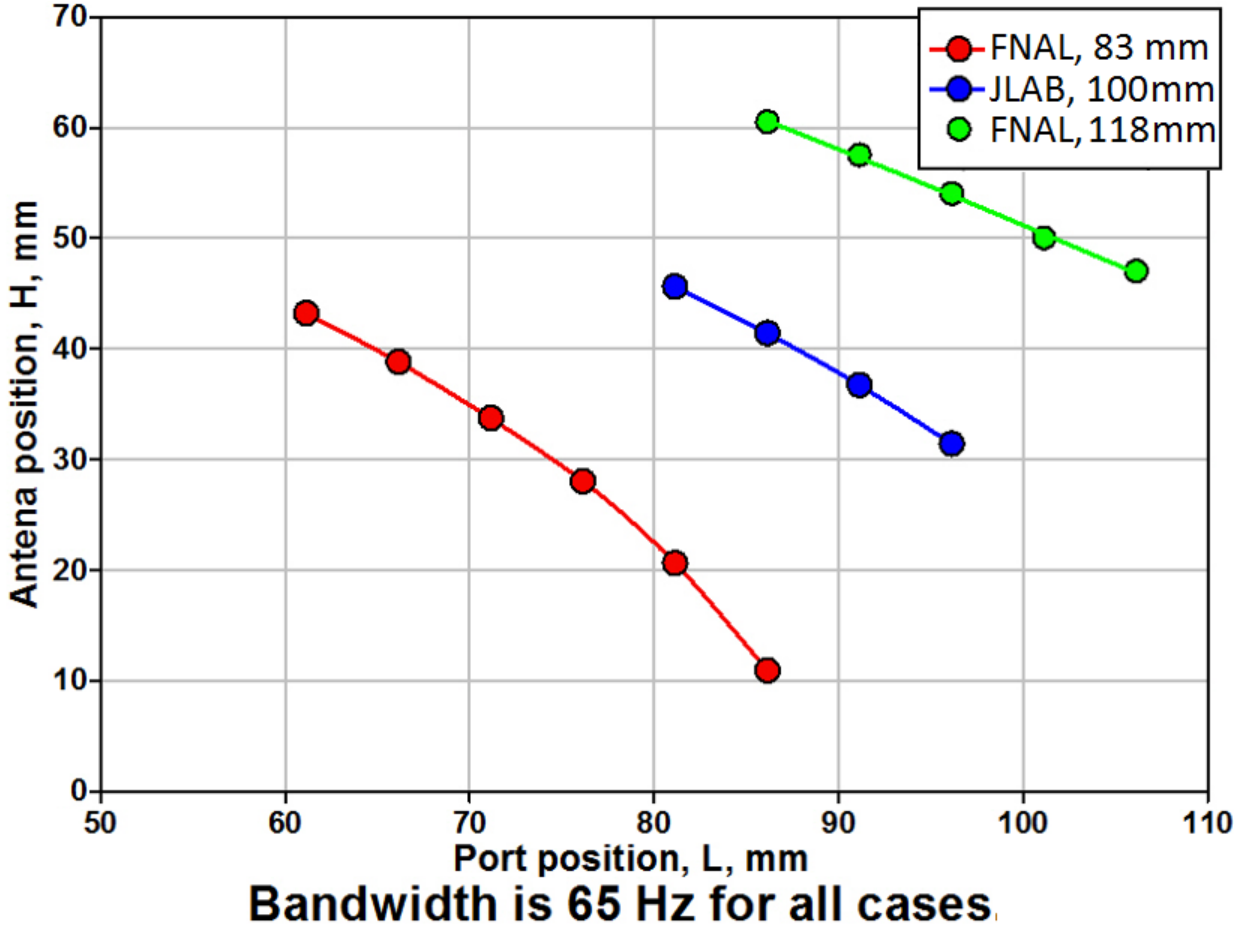




Coupler position for 2 mA

LB650 cavity why 118 mm beam pipe

- 650 MHz power coupler and LB650 cavity



Bandwidth is 65 Hz for all cases

RF parameter of new design of LB650 cavity

- RF design summary

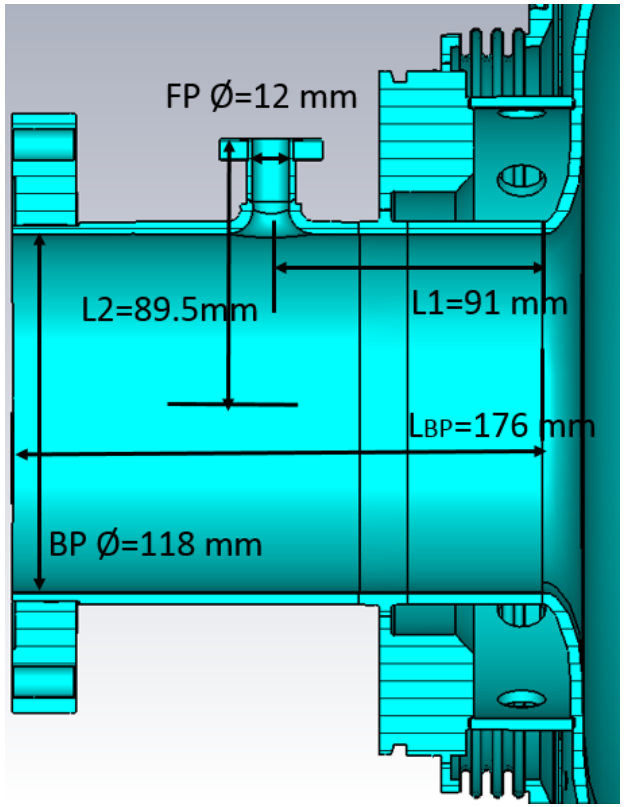
Parameter	FNAL	JLAB	FNAL	Change
	83 mm	100 mm	83/118 mm	%
β_G	0.61	0.61	0.61	
β_{opt}	0.647	0.645	0.65	
$R/Q(\beta_{opt})$, Ohms	377	317.5	356.3	-5.5
$E_{surf}/E(\beta_{opt})$	2.26	2.64	2.33	3.1
$B_{surf}/E(\beta_{opt})$, mT/(MeV/m)	4.21	4.64	4.41	4.8
G, Ohms	191	185	187	-2.1
G*R/Q	72007	58737	66628	-7.5

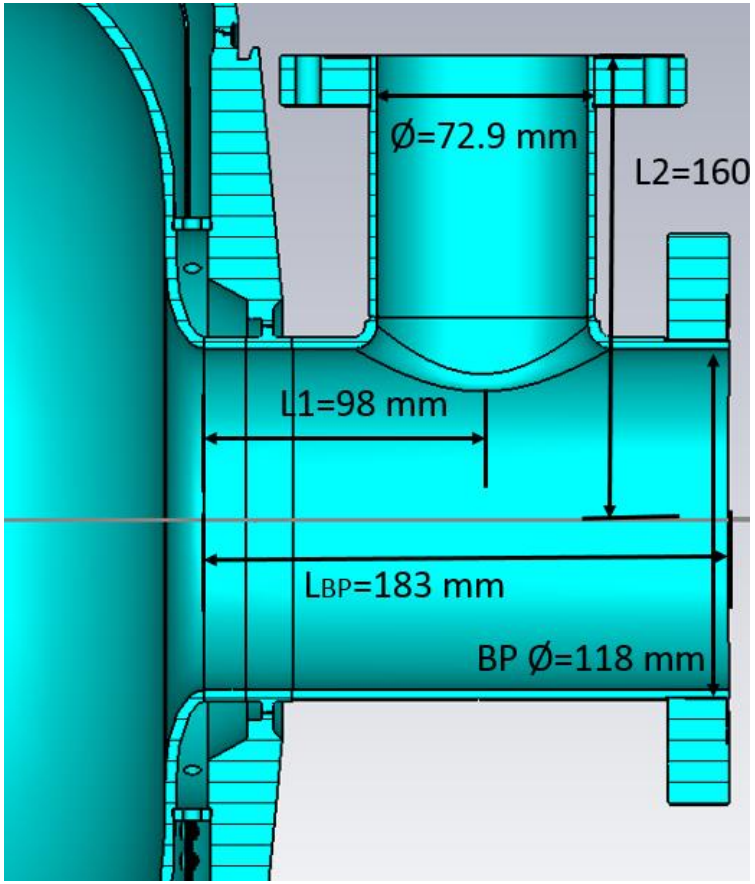
LB650 cavity new design summary

- Easy integration of coupler and tuner
- Same end assembly as for HB650
  - Optimized for low df/dP and LFD
- Same as for HB650 parts of beam assembly
- Same as for HB650 bellows between cavities
- Same as for HB650 power coupler with same antenna length
- Same as for HB650 interface for tuner
- Electrodynamic parameters are not sacrificed significantly:
  - Higher surface magnetic fields by only 4.8 %
  - RF losses on cavity walls increased by only 7.5 %

Additional slides

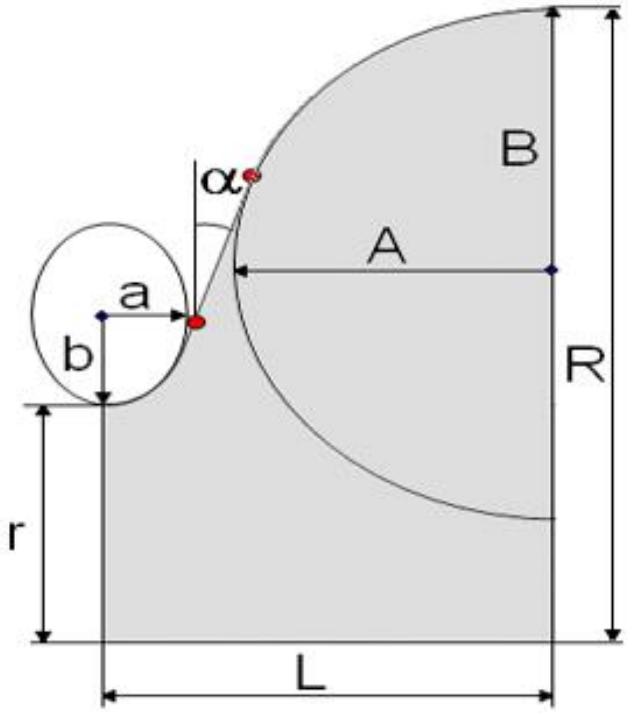
- Major dimensions of LB650 cavity end assembly





Additional slides

650 MHz, beta=0.61, 5 –cell cavity geometry



"COLD" (As Designed)

End cell		Mid cell	
r	59	r	41.5
R	194.95	R	194.95
L	68.365	L	70.34
A	54	A	54
B	48	B	58
a	14	a	14
b	26	b	25
α	0.7°	α	2°

"WARM" (As in Drawings)

End cell		Mid cell	
r	58.884	r	41.36
R	195.03	R	195.03
L	68.46	L	70.44
A	53.88	A	53.88
B	47.87	B	57.88
a	14.22	a	14.22
b	26.24	b	25.235
α	0.7°	α	2°